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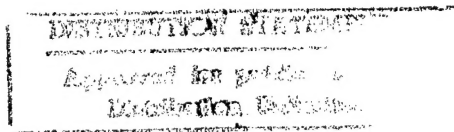
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**Army Logistics
Assessment Program**

Prepared for

HQ USA/DALO-RMI
500 Army Pentagon
Washington, DC 20310-0500

14 June 1996



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The proof-of-concept model for ALAP demonstrates the feasibility of equating Army measures of OPTEMPO, maintenance rates, and funding levels to sustainment capability. Synergy's ALAP shows that we can link weapon system readiness to sustainability given current and future programmed budget positions to create a viable POM and PPBES decision-support tool. This model also supports the hypothesized outcome of current funding levels affecting future capabilities to successfully prosecute combat missions and contingency operations.

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LIST OF ACRONYMS

ALAP	Army Logistics Assessment Program
AMC	Army Materiel Command
BES	Budget Estimate Submission
DBOF	Defense Business Operations Fund
DLR	Depot-level reparable
DMP	Depot Maintenance Program
DOD	Department of Defense
FAMMAS	Funding/Availability Multi-Method Allocation for Spares
FYDP	Future-Year Defense Program
GUI	Graphic user interface
MACOM	Major Command
MC	Mission Capable
MDEP	Management Decision Package
MPDI	MACOM POM Development Instructions
MPDL	Master Profile Data List
MSC	Major Subordinate Command
NMC	Not Mission Capable
NMCM	Not mission capable, maintenance
NMCS	Not mission capable, supply
OPTEMPO	Operating tempo
OSD	Office of the Secretary of Defense
OSRAP	Optimum Stockage Requirements Analysis Program
PAED	Program Analysis and Evaluation Directorate
PB	President's Budget
PBG	Program Budget Guidance
PEG	Program Evaluation Group
POC	Proof Of Concept
POM	Program Objective Memorandum
PPBES	Planning, Programming, Budgeting, and Execution System
PPBS	Planning Programming and Budgeting System
SMBA	Supply Business Management Area
TAP	The Army Plan

SECTION 1

INTRODUCTION

This section is to give the reader an understanding of the atmosphere in which this project was undertaken. The underlying intent is to highlight the fact that time for completion was the critically short resource, and that functionality was cut from the proof-of-concept model to stay within the allocated time. If the tone suggests a laying of blame, pointing of fingers, or the making of excuses for action taken or not taken, it is purely incidental. The goal is to impress upon the reader that the study and analysis support the development of a robust, rapid analysis, microcomputer-based model.

1.1 BACKGROUND

The Army's interest in the Funding/Availability Multi-Method Allocator for Spares (FAMMAS) model, and the subsequent contract for Synergy's Army Logistics Assessment Program (ALAP) began in the Fall of 1993 when the Meyers Readiness Task Force, charged with exploring means of improving Force Readiness throughout the DoD, identified FAMMAS as a model worthy of being adopted by all of the Armed Services. By December 1993, Gen Salomon, then the Army Deputy Chief of Staff for Logistics, became aware of the model and directed that FAMMAS be tested using the AH-64 (Apache Attack Helicopter). The AH-64 test was successful and the go-ahead was given to test three additional helicopter systems. Analysis for the CH-47D, OH-58D, and UH-60 systems were equally successful. The next step was to validate FAMMAS against ground-based weapon systems to completely assess the model for use as an Army decision-support tool.

The ground system test used the Bradley Fighting Vehicle System (M2/3), and the M1 Abrams Main Battle Tank. FAMMAS successfully concluded this test as well as the last series involving 13 of the Army's 16 designated Status of Resources and Training Systems (SORTS) weapon systems. After these favorable conclusions, the Secondary Items Division, Office of the Deputy Chief of Staff, Logistics (DALO-RMI), negotiated with Synergy to develop an Army version of FAMMAS in the Windows graphic users interface (GUI) environment. In addition, Synergy was to enhance FAMMAS with attributes the Air Force version did not have.

At the inception of work on Army FAMMAS, interest was high and the program enjoyed a considerable amount of visibility within the Army Staff. Management of the project resided in ODCSLOG at DALO-RMI. However, personnel changes within the Army Staff, ODCSLOG, and DALO-RMI worked to change the Army's focus, and interest in the project began to fall. Ultimately, management for this development effort

shifted to Headquarters, Army Material Command (AMC), but control remained at DALO-RMI. This arrangement lead to a situation where there were, for all practical purposes, two project directors with different agenda that had to be satisfied. The effect of this had a direct impact on the development of both Army FAMMAS and ALAP. ALAP, however, was affected the most, and all but the most essential work under this contract stopped for several months until DALO-RMI gave a definitive go-ahead.

1.2 FAMMAS

FAMMAS is a parametric model that the Air Force used extensively to project aircraft readiness rates based on the authority to obligate depot-level reparable (DLR) dollars. FAMMAS has also been adopted for use in Program Objective Memorandum (POM) assessments (readiness projections) and provides the readiness complement to a suite of models Synergy developed for the Air Force, known as the Logistics Assessment Models (LAMs). Under contract to DALO-RMI, Synergy revised FAMMAS for the Army's use and developed the model as a microcomputer-based program with a Windows-type GUI, written in Borland's Delphi. It is designed to assess projected spares support and manpower availability to future weapons system materiel readiness. Army FAMMAS links funding for DLR spares and repair to expected weapons system not-mission-capable for supply (NMCS) rates. Army FAMMAS also relates projected equipment usage (OPTEMPO) and repair potential (manpower levels and utilization) to not-mission-capable for manpower (NMCM) rates. Army FAMMAS uses dynamic, interactive displays that are backed by cost models and parametric equations to quickly estimate the effect on not-mission capable (NMC) rates of different levels of wholesale level operating cost authority (OCA) allocated to key accounts in the Supply Business Management Area (SBMA) segment of the Defense Base Operations Fund (DBOF).

1.2.1 FAMMAS NMCM MODULE

The NMCM module to FAMMAS that applies OPTEMPO to weapon systems to measure the maintenance side of weapon system readiness was an ALAP effort. A brief overview of that module follows. For detailed discussion of the maintenance module to Army FAMMAS, please see the technical report, functional description, and users manual.

The maintenance module is the portion of Army FAMMAS that addresses the effect of manpower on weapon system availability rates. This module operates independently of the NMCS module and uses different input data. NMCM values are predicted for future years based on the expected activity of a system (OPTEMPO) and the manpower available to repair it.

A study was done of existing NMCM data and the factors that correlate with them (personnel available to perform maintenance, minimum number of hours required to maintain a particular weapon system, frequency of system use, and OPTEMPO). The analysis of data showed that NMCM values in a particular year are related to the manpower available in that year for repair work, but are related to OPTEMPO more closely in the year prior to the year in question, rather than that year itself.

The actual study was more in-depth and considered the relationship of supervisory personnel and what impact they had on the maintenance posture. The direct maintenance personnel's ability to effect system repair was studied as well as the supervisor to direct maintenance personnel ratios, and fill rates. All these factors had relevant impact on the NMCM for weapon systems. This information was to be applied to ALAP as well as to FAMMAS. However, it was deemed inappropriate to use logistic development funds to investigate and study personnel data. This decision meant that the projections developed from the NMCM module would not be as accurate as had originally been planned.

1.3 ALAP

The Army Logistic Assessment Program was a project with a broad concept to enhance the Army version of FAMMAS in several ways. It called for the development of a set of algorithms to effect the mission capable rate projection of FAMMAS to reflect the impact of weapon system reliability and maintainability caused by programmed modifications, depot maintenance, and common support equipment. The secondary effort of the program was to perform wartime logistics assessments in support of the Army's 16 SORTS weapon systems; and to adopt standard Army OPTEMPO measures for use within FAMMAS and a wartime model as required.

The architecture for the model developed for the ALAP project will take the NMCS and NMCM projection results of Army FAMMAS, run it through a wartime scenario and provide the users with a weapon system availability status. In essence, develop a wartime model that would allow the logistics community to graphically display how current budget shortfalls affect the weapon system capability or to sustain the system in combat situations.

The most unfortunate incident to occur within the entire ALAP project was the decision to introduce it as a wartime model. The thinking within HQ AMC was that the Army was adequately represented by wartime modeling efforts (the primary model being OSRAP, which was developed by the U.S. Army Materiel Systems Analysis Activity [AMSAA]) and no others were required.

OSRAP is a stockage computation and requirements model designed to compute sustainment requirement for any sized task force. The model calculates operating levels and reorder points for class IX items, with the goal of producing an optimum stockage solution while meeting the desired performance goals of the supply system. This model can also be used to determine stock under a fixed set of parameters or it can be used to perform sensitivity analysis with user-adjusted input parameters. The model uses the Candidate Item File (CIF) developed by the Major Subordinate Commands (MSCs) and combat damage information for spare parts damaged during combat. Combat damage data are obtained from the Sustainability Predictions for Army Spare Components Requirements for Combat (SPARC) methodology. OSRAP is a sophisticated model that uses numerous databases containing detailed weapon system-specific information. It is capable of completing various types of analyses, but the model's specific purpose is to determine what stockage should be on hand to meet specified availability levels at various echelons.

1.4.1**PROGRAMMED MODIFICATION, DEPOT MAINTENANCE, AND
COMMON SUPPORT EQUIPMENT**

During June 1995, Synergy was several months into the ALAP contract and, with the exception of identifying OPTEMPO for the SORTS weapon systems, little work had been performed on the contract. The situation was made more tenuous because AMC had just taken management responsibility for the project, and the opposing views for the need of a "Wartime FAMMAS" (ALAP was originally referred to as a Wartime FAMMAS) were the impetus to look to completing the other work specified in the contract. HQ AMC was approached for coordination with developing the programmed modification, depot maintenance, and common support equipment enhancement to Army FAMMAS (Synergy's proposal appears as Appendix A). This idea was originally warmly received, but after further consideration, turned out to be an option AMC chose not to pursue.

1.4.2**PROOF-OF-CONCEPT MODEL**

In November 1995, DALO-RMI directed that the ALAP project proceed with the wartime analysis. There were now 2 months left to complete work on the contract, and the only work that had been accomplished was the development of the maintenance data for Army FAMMAS. A 6-month, "no cost, time only extension" was immediately requested. The statement of work was altered to read that a proof-of-concept model would be

developed vice a wartime model, and work hurriedly began to complete a development effort that began and stopped 12 months prior.

1.5

SUMMARY

The ALAP project, if allowed to proceed as originally envisioned, would have been a project to enhance Army FAMMAS and to develop a very useful and complementary decision-support tool.

The research and study that supported the development of the NMCM module of Army FAMMAS was developed under ALAP and was intended to serve as the bedrock for the ALAP "wartime/sustainment" model. A decision not to use the Military Occupational Specialty Leveling System (MOSLS) data resulted in a loss of accuracy in the prediction of NMCM rates and caused the redesign of the architecture for the ALAP proof-of-concept model.

This NMCM analysis effort became moot because of a change in personnel causing changes in perception of the model's worthiness and utility to the Army's logistics community. This unfortunate incident was only one example of the disjointed work schedule that came to characterize the nature of the entire ALAP project. From the initiation of work on this project, development was slow because of the erroneous character given to the program. Because it was originally briefed as a wartime model, it was immediately perceived as a change to OSRAP.

This perception caused approval and support to be withheld for any development effort until close to the project's scheduled completion date. When approval to restart work under ALAP was finally given, very little time remained on the contract (2 months). A request for a "Time only, No cost" extension to the contract was hurriedly prepared and submitted. The result is a proof-of-concept model limited in its scope and functionality.

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SECTION 2

PROBLEM

2.1

BACKGROUND

Operational capability is initially designed into a weapon system and then supported with an expensive array of resources that are in every sense a part of the system's capability. Spare parts and the repair skills to install them are a central part of the weapon system's capability package because they determine system mission availability. Unfortunately, the recurring nature of a weapon system's supply and maintenance costs make it vulnerable to budget cuts as other weapon systems and programs compete for limited defense resources. There is, therefore, a continuous need to provide accurate input to the Planning, Programming Budgeting and Execution System (PPBES) process to justify and balance expenditures that sustain operational capability.

The Planning, Programming and Budgeting System (PPBS) is a cyclic (biennial) process used to develop a plan, a program, and a budget for the DoD as outlined in DoD Instruction 7045.7. It provides a framework for making decisions on current and future programs through three interrelated phases (planning, programming, and budgeting), consistent with national security objectives, policies, and strategies. The Secretary of Defense (SECDEF) provides centralized policy direction throughout the cycle, while giving the Military Departments (Services) and DoD agencies the authority to execute the program.

The PPBES is the Army component of the DoD PPBS. It is the Army's primary strategic management system used to allocate and manage resources. Its objectives are to provide the national military strategy in: sizing, structuring, and manning of the Army force; obtaining required forces, manpower, materiel, and dollars; allocating forces, manpower, materiel and dollars among competing demands according to Army resource allocation policy and priorities; and evaluating how well execution of the program and budget applies resources to achieve intended purposes and adjust resource requirements based on execution feedback. This adjustment process within the programming, budgeting, and execution phases of the PPBES process is continually dynamic and ever-changing, forcing Army logisticians to operate under extreme time constraints. Consequently, Army logistics managers are frequently asked to provide estimates of the effects of funding and personnel policy changes on their systems from day to day and hour to hour as negotiations at higher levels either increase or decrease the resources allocated to them.

Models have been available to the Army to do such estimates, but these models require time for acquiring and changing data inputs, as well as time to run. While the time to run one case may be acceptable, when several

alternatives are being evaluated concurrently (and the parameters of these alternatives may change from hour to hour), the running time of the models may be too great to allow for timely feed back. The result is that back-of-the-envelope estimates are made to satisfy requests for information. The process is described in more detail below.

2.1.1 PLANNING, PROGRAMMING, BUDGETING, AND EXECUTION SYSTEM (PPBES)

The PPBES is the Army's primary management system. Constituting a major decisionmaking process, the PPBES interfaces with the Office of the Secretary of Defense (OSD) and joint planning, and links directly to OSD programming and budgeting. It develops and maintains the Army position of the Defense program and budget. It supports program and budget development by both Headquarters and field organizations. During execution, it provided feedback to the planning, programming, and budgeting process. The process formalizes the methodology for developing, assessing, validating, and defending Army funding requirements.

The PPBES concept ties strategy, program, and budget together. It helps to build a comprehensive plan in which budgets flow from programs, programs from requirements, requirements from missions, and missions from national security strategy objectives. The patterned flow — from end purpose to resource cost — defined requirements in progressively greater detail.

For the Army logistics community, the PPBES process begins with the MSCs determining the level of logistics resources necessary to support their weapon systems. These requirements are sent to the AMC for consolidation and verification before being presented to the Army Staff for funding. The Army Staff consolidates and prioritizes these Future Year-Defense Programs (FYDPs) for submission to OSD. OSD then submits the FYDP to the president, who in turn forwards it to congress as the President's Budget (PB). This is a highly simplified version of the PPBES process, and there are many iterations of the funding requests before the FYDP is finalized in the PB.

The weapon system management community described here consists of the Army Deputy Chief of Staff, Logistics, HQDA (DCSLOG), the Deputy Chief of Staff for Operations and Plans HQDA (DCSOPS), and HQ AMC, with its MSCs. This community has a major forecasting responsibility. It must look 6 years into the future; understand the peacetime and wartime force structure requirements; document the peacetime and wartime logistics requirements to support that force structure; cost the logistics requirements; defend the request through the budgeting process; procure, store, and allocate the resources; and track all funding from

appropriation to expenditure (to ensure maximum support per dollar). AMC is always subject to oversight of its management of secondary items (spares) and the 2- to 5-year acquisition cycle required from placement of initial orders until new items appear in the system. Additionally, with an inconsistent budget, the force structure is in a constant state of flux. Because force structure determines logistics support requirements, a continually changing force structure, combined with an inconsistent (and independently developed) funding level, creates significant problems for Army logisticians who must now obligate funds for spare parts for repair of weapon systems 2 years from now. If the force structure expands too quickly, as in the early 1980's, procurement lead time for logistics support cannot keep up with the immediate demand for resources. If the force structure shrinks too quickly or is unstable, as in the late 1970s and early 1990s, the lead time requirements result in too much logistics support for weapon systems being retired sooner than originally planned.

Although there are several mainframe computer systems within the weapon system management community to assist in defining logistics requirements, these large systems are encumbered by the substantial amount of data needed for detailed computations and the time taken to do these computations. Often, the mainframe systems are unable to respond on short notice to HQDA staff inquiries requiring analysis, either because they are not easily accessible, because they require intensive manual data entry, or simply because they take too long to operate. This severely limits logistics planners as they attempt to identify, isolate, and balance the shifts in funding and spare parts inventories.

2.2

EXISTING METHODS AND PROCEDURES

In general, DALO-RMI relies heavily on HQ AMC with its MSCs to produce justification for weapon system adjustment and alternatives, and finds that it is difficult to obtain timely assessments of proposed programmatic adjustments.

2.2.1

EXISTING LOGISTICS INPUT TO FORCE ASSESSMENTS

Capability analyses are normally performed on approved force structure values submitted after the PPBES POM, Budget Estimate Submission, and PB exercises. Because of the timing of these evaluations, any capability shortfalls are highlighted after the force structure approval process. Because of the nature of most mission areas, corrections of these shortfalls are implemented quickly with the promise that the funding will be provided at the beginning of the next budget exercise. If the correction has an impact on logistics, the adjustment in logistics funding to the program cannot be incorporated until the start of the next exercise.

2.2.2

EXISTING PPBES SUPPORT

Although the offices of the DCSLOG, DALO-RMI, and AMC are highly visible during the PPBES process, their level of participation is sometimes limited by their staffs' inability to respond with timely, in-depth analyses of funding alternatives within the fast-paced PPBES process. For example, the following generic actions take place during preparation of the Army POM in the programming phase of the PPBES.

The biennial process of updating the Army's POM is divided into three phases: HQDA issues program guidance to the Major Commands (MACOMs); MACOMs write and submit their POMs to HQDA; and HQDA develops and submits the Army POM to OSD.

There are three primary programming guidance documents that form the administrative boundaries within which the MACOMs and the Army POM are written: The Army Plan (TAP), the MACOM POM Development Instructions (MPDI), and the Program Budget Guidance (PBG). Because of the unparalleled global changes that have taken place over the past several years, resources available to DoD and especially the Army are being severely constrained. The resource guidance contained in the PBGs apportion those reductions to the MACOMs and place specific constraints upon the MACOMs.

Receipt of the fiscally constrained PBG is the starting point for writing the MACOM POM. If a MACOM's PBG resources are less than its total requirements, the MACOM commander must determine how to realign PBG resources to best satisfy requirements. Within the confines of TAP guidance, MACOMs must conduct trade-off analyses to determine which requirements — in the form of management decision packages (MDEPs) — must be fully resourced, which ones can be partially resourced, and which MDEPs, if any, can be emptied of all resources as bill payers for higher-priority MACOM needs.

Upon receipt of the MACOM POMs, PAED verifies that the data received conform to the reporting requirements defined in the MPDI. The data are loaded into the HQDA Decision Support System, which is a computer network in the Pentagon accessible to all Army POM developers. Key among these developers are the Program Evaluation Groups (PEGs). PEGs oversee resources from a functional or program perspective. Every MDEP is assigned to only one PEG based on the predominant appropriation within the MDEP.

PEGs build the Army program at the budget level of detail by first reviewing and validating MACOM POM submissions. They verify that MACOM submissions meet HQDA guidance. They check MACOM-proposed zero-sum realignments of resources, identified bill payers, and unresourced programs. MACOM program

realignments that conflict with HQDA guidance are returned for revision. If they cannot be resolved, the are elevated to the Program and Budget Committee for resolution. PEGs also check unresourced program lists to determine if MACOMs have included must-fund issues. If any are found, the PEG requires the MACOM to resource these programs.

PEGs are thus program validators and integrators. They evaluate MACOM resourcing issues, enforce HQDA program guidance, and identify and resolve programmatic disconnects that are only visible at HQDA level. PEGs are also the mechanisms for spreading OSD-directed fiscal decrements at the eleventh hour of POM development.

The scope and difficulty of POM development at HQDA can vary widely depending upon two major factors. The first is the quality of the MACOM POMs. If the MACOMs constrain themselves to the fiscal limitations placed upon them and do so within the programmatic guidance published by HQDA, the POM development process at HQDA is greatly streamlined. The second factor is how closely the resource levels in the POM PBG match the final OSD topline fiscal guidance imposed on the Army (OSD usually publishes these controls after the MACOM POMS have been written and submitted). In a perfect world, final OSD fiscal guidance issued to the Army should match the topline fiscal assumptions used by HQDA during drafting fiscal guidance to the MACOMs. However, in reality, OSD fiscal guidance is usually at variance for many reasons. The development of the POM, therefore becomes a HQDA-driven process that matches resources to missions in a rapidly changing fiscal environment.

The rapidly changing fiscal environment, coupled with the current fiscal constraints being placed upon all Army MACOMs, many times does not allow enough time to cost each program alternative properly or in sufficient detail to establish operational or logistics impacts. A macrolevel estimate is usually developed initially and refined after the exercise. As noted previously, any funding problems are adjusted at the beginning of the next PPBES several months later.

Any resource model that can rapidly portray the impacts of alternative funding streams upon the Army's major weapons system would be a powerful tool to assist the Army logistics community in the constant defense of their logistics resources

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SECTION 3

SOLUTION TO THE PROBLEM

From a weapon system viewpoint, operational capability is expressed in terms of readiness and sustainability. Readiness is defined as the weapon system's availability, maintained in peacetime, that can be drawn upon at the commencement of hostilities. Sustainability is defined as the continuing availability level that can be supported during the conflict given the expected OPTEMPO.

Weapon system availability is defined as the proportion of total time during which a system is not down for lack of parts (NMCS) or down for maintenance (NMCS). It can also be described as the proportion of the total number of weapons available for a mission at a given time. Commanders typically add another dimension to readiness. A complete look at the readiness of combat forces demands that the people who operate and maintain weapon systems function at peak effectiveness. Personnel readiness demands expenditure of resources while equipment readiness seeks to preserve stocks of resources at some target level. Most readiness assessment models look at one side of this relationship, seldom giving both perspectives simultaneously. It was ALAP's intent to treat both perspectives and assist planners in balancing this delicate equation.

Peace and war are contiguous on a timeline. One day we are at peace, the next day we may be at war. Therefore, the ability to sustain combat operations is dependent on the same resources (and state of readiness) that existed the day before war began. While modeling the ability of a force to sustain wartime operation is different from modeling readiness issues, the resource base should be the same and initial peacetime readiness defines the outcomes of the early days of combat. For this reason the Army FAMMAS and ALAP models were joined. The models offer similar goal methods of analysis and support. Together, the models present a complementing readiness/sustainment analysis.

With the concepts of resource trade-offs in peacetime readiness and materiel consumption during wartime operations as its bases, FAMMAS/ALAP creates a unique framework for analysis using data and computational procedures. The model draws on evolutionary improvement in cost analysis and availability modeling. It builds on this foundation using techniques of interactive data display and manipulation that rely on advanced concepts of information processing for microcomputers. The model provides a way to look at resource relationships in a manner that will permit their rapid application to analysis in support of the programming and budgeting process.

From a technical viewpoint, the Army FAMMAS/ALAP model can best be described as a system of interrelated models using dynamic, interactive displays that are grounded in cost models and parametric equations and that rely on common data sets, and a supporting external File Management System. The model is characterized by a unity of concept and design that users will quickly come to appreciate.

The general approach to the design of the Army FAMMAS/ALAP was to develop a menu-driven Windows program written in a state-of-the-art Windows programming language. (Delphi, Borland's new Windows programming language, was picked for this effort.) The methods that had been successfully used in the construction of the FAMMAS model for the Air Force were incorporated into the Army version of both models, with certain changes and improvements to Army FAMMAS over Air Force FAMAS. The NMCS predictor was modified to eliminate minor problems (such as predicted values of NMCS less than 0 or greater than 1 in rare instances), and an algorithm was added to allow the user to spread funds automatically over several weapon systems in a variety of ways to satisfy optimality and other criteria, without the need for the trial and error approach that had been used for previous spreading problems. Also, a predictor for NMCM was added.

The resulting Army FAMMAS/ALAP model is a parametric model operating on a microcomputer whose calculations are based on the major resource and utilization factors that affect NMCS and NMCM rates — namely, required funding for DLR spares, obligated funding for spares, usage rates for equipment, and repair capability for equipment. The required inputs for this model are fairly straightforward. Funding levels are by weapon system, in millions of dollars, and are for the standard categories of DLR spare parts buy dollars, DLR initial spares dollars, consumables dollars, and DLR repair dollars. NMCS is predicted using these values and the target NMCS figures that were used to compute the required amounts in each of the categories. Usage rates, which are used in the calculation of NMCM estimates, are in OPTEMPO terms, whenever OPTEMPO is defined for a system. (If OPTEMPO has not been defined and data collected for a system, then the model does not try to predict NMCM but merely extends the trend of values from previous years for that system.) Repair capability, also used for calculation of NMCM estimates, is expressed in terms of manpower fill and utilization rates. Although there are certain parameters that must also be input to the model (such as the time lag for delivery of purchases), these are the basic inputs for Army FAMMAS. However, the joining of FAMMAS with ALAP necessitated additional inputs such as combat or wartime usage rates from the Master Profile Data List (MPDL), which are used to replicate weapon system OPTEMPO in various theaters of probable or possible conflict. Parts and subcomponent failure and breakrates are calculated from the Mean Unit Between Breakrate (MUBR) data as they are reported in the CIF, and the NMCS and NMCM rates calculated by Army FAMMAS are inputted into ALAP as supply and maintenance parameters. Data for these inputs have

been found to be available for all systems considered (with the exception of OPTEMPO information for certain systems).

Unlike the large models, the Army FAMMAS and ALAP model will be quickly accessible, and PPBES data developed before, during, and after the PPBES process can be updated electronically in the model. When supported by near real-time recomputation of the operational impacts of funding changes on the weapon system's materiel readiness and sustainability, Army logistics managers can respond with authority in time to influence major decisions, or to answer the question, "Given today's funding, would the Army be able to support the President's National Security Objective of the successful simultaneous prosecution of more than one Major Regional Conflict?" As a consequence, the logistics community should be able to provide a more responsive level of support to HQDA and AMC by quickly identifying the impacts of alternative funding positions and by providing graphical documentation of those impacts on the materiel readiness of the Army's major weapons systems. The speed of the model allows the user to consider several alternatives concurrently and to turn out reasonable estimates of the effects of these alternatives within a matter of minutes. Outputs of the model can be customized to be used for presentation to the requesting authority.

3.1 FAMMAS/ALAP OBJECTIVES

For Army FAMMAS/ALAP to be effective, it must produce timely, accurate, and analytically sound readiness assessments based on specific resource profiles. Therefore, Army FAMMAS and ALAP have the following objectives:

Provide an interactive modeling capability that integrates DLR funding levels with weapons systems materiel readiness assessments.

- Maintain consistency in the treatment of data among the various budget advocates at HQDA, HQ AMC, the MSCs, and the MACOMs.
- Define the relationships between a variety of weapon systems-related resource funding.
- Prepare timely, accurate, and analytically sound estimates of the impacts of funding changes on weapons system materiel readiness for weapon system advocates in the PPBES process.

- Provide a rapid modeling capability with universal applicability.
- Provide a portable modeling capability that can be used in multiple geographical locations and that is self-contained in terms of data support.

3.2

PROPOSED METHODS AND PROCEDURES

Army FAMMAS and ALAP will provide a new analytical capability that will assist weapon system planners as they develop, advocate, and defend the Army structure position. Army logistics managers will be able to produce timely, accurate, and analytically sound justification for the requested secondary items funding that impact upon the materiel readiness of the Army's major weapons systems.

The following section presents procedures to perform the cost and capability assessments. The overall intent of these procedures is to allow Army Staff advocates to raise their profile in assessing alternative Supply Management Business Area (SMBA) program adjustments of Defense Business Operations Fund (DBOF).

3.2.1

PROPOSED PPBES SUPPORT

Logistics impact estimates on weapons system materiel readiness help eliminate those options that are unacceptable and highlight those options that warrant further investigation. If necessary, SMBA DBOF funding stream-based alternatives can be developed independently for consideration. Assuming the potential for trade-offs, the appropriate action officer presents the Army FAMMAS and ALAP results to the proper committee, group, or agency for deliberation. Upon request, Army FAMMAS will also produce additional alternatives for consideration and, if need be, those considerations can be run through ALAP to determine how the alternatives would support sustainment of the force in a combat/contingency situation.

Since Army FAMMAS and ALAP will provide analytically and operationally sound results, any recommendations to the groups, committees, or agencies participating in the PPBES process will have a higher probability of final acceptance without having to revisit the alternatives later in the process. If revisits are necessary, Army FAMMAS will continue to produce real-time evaluations of weapons system materiel readiness based upon SMBA DBOF funding streams in support of the PPBES process. Army FAMMAS logistics assessments will prepare the Program Evaluation Group (PEG) monitors to advocate analytically sound alternatives for funding consideration.

Army FAMMAS provides an operationally oriented rationale for adjusting a funding profile in the required format for immediate presentation to the Army Staff. The development and evaluation of alternatives will be nearly instantaneous, with on-screen graphics suitable for large audience projection, automatic report generation for distribution, and electronic file creation for error-free data transfer.

During this process, the approved cost factors and program data are used to maintain data consistency among the various force structure advocates at the Army Staff and MACOM organizations.

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SECTION 4

SUMMARY

The proof-of-concept model for ALAP demonstrates the feasibility of equating Army measures of OPTEMPO, maintenance rates, and funding levels to sustainment capability. Synergy's ALAP shows that we can link weapon system readiness to sustainability given current and future programmed budget positions to create a viable POM and PPBES decision-support tool. This model also supports the hypothesized outcome of current funding levels affecting future capabilities to successfully prosecute combat missions and contingency operations.

The central theme of the ALAP proof-of-concept model is to show that an assessment and decision-support tool can be developed that allows the decisionmakers to run sustainment scenarios based on the current or proposed budget and availability posture for any specified weapon system. Because the intent is to model a weapon system's availability from peace to war, two outputs from Army FAMMAS are used as the starting points for ALAP. The NMCS and NMCM rates projected by Army FAMMAS are used to replicate the supply and maintenance availability at the start of hostilities. Other input factors include parts and component breakrates calculated from the CIF, the MUBR also taken from the CIF, and wartime OPTEMPO rates as reported in the MPDL.

In the most simplistic of terms, ALAP takes a given weapon system, applies doctrinal rates of combat operation, and calculated rates of component parts breakage to simulate parts failures under combat conditions. After the system is deadlined, the model attempts to repair the weapon by applying observed or predicted (depending on the scenario year, past years would be observed and future years would be predicted) rates of supply and maintenance availability. By using the supply availability rates from FAMMAS, the decisionmaker has a graphical representation of what effects current budget constraints has on the Army's capability to simultaneously prosecute multiple MRC.

At the project initiation, Synergy had envisioned developing a robust model capable of fast turn around and accurate portrayal of Army weapon system availability and the logistics system sustainment capability. The original intent was to allow the model to deploy a combined arms mix of weapon systems, similar to how the Army would actually deploy. Synergy had also planned to replicate, as accurately as possible, the availability of maintenance personnel by using data provided from the Personnel Commands Military Occupational Specialty Leveling System (MOSLS) model. The use of MOSLS data for ALAP was considered because the sustainment model would weigh the maintenance data more heavily than the supply data, just as the Army

FAMMAS model relies more on the supply function than on the maintenance. The theory was that during contingency operations, the availability of trained maintenance personnel was the primary factor to sustainment. While availability of parts is the major issue in peacetime, recent events show that when a unit deploys it does so without lacking parts. An organization may occasionally experience a slow down in the delivery of requested class IX, but every effort will be expended to ensure the timely arrival of the requested supply. The availability of personnel, however, is such that if there are no trained maintenance personnel on hand or available, the capability to sustain a weapon system is significantly degraded and may not recover during the time frame of the contingency operations. Finally, the originally conceived ALAP model would allow the user to analyze the logistics system's ability to sustain a weapon system based on varying categories of OPTEMO. The type and amount of categories would depend on the system. For example, a close combat system such as the M1 Abrams has component parts that are tracked by hours of operation, miles driven, and rounds fired; it was Synergy's intention to build into the model the capability to analyze the resources needed to sustain this weapon system based on all applicable OPTEMPOs and to develop the capability to analyze the system as one major end item.

The ability to portray the maintenance capability to an accuracy that matched DCSPER projections of future manpower levels was lost when personnel from DALO-RMI decided it was inappropriate to spend logistics money to study personnel issues, and the plans to integrate the ability to perform sustainment analysis based on various categories of OPTEMPO were relinquished because the very short development time did not afford adequate opportunity to gather or complete the needed study of data and data sources.

In an attempt to overcome this dilemma, the decision was made to use the derived NMCM rate produced from Army FAMMAS. ALAP takes the 1-NMCM rate produced by an Army FAMMAS run to generate the maintenance capability to return weapon systems in need of repair back to mission capable conditions, and instead of doing analysis on all possible OPTEMPOs, the model is limited to hours of operation. This portion of the proof-of-concept model could be enhanced significantly given the opportunity to replace it with the original architecture.

Another item requiring future study is the integration of a model similar to the Army FAMMAS/ALAP, with OSRAP to create a true requirements to readiness/sustainability model.

APPENDIX A

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A PROPOSAL FOR MODELING SUPPORT OF DEPOT MAINTENANCE PROGRAM (DMP) ANALYSES AND ASSESSMENTS

Synergy has developed a creative and comprehensive approach for determining the relationship between weapon system mission capability and budget programs for the Army's Depot Maintenance Program. In this proposal we will describe how we would prepare ourselves for the task and how we believe we can build an analysis system that will meet a range of modeling requirements for relating DMP policies, costs, and weapon system readiness.

1 PROPOSED APPROACH

Our proposed approach to analysis of Depot Maintenance Program (DMP) describes the problem (Section 1.1), demonstrates our understanding of the problem (Section 1.2), and presents our detailed action plan (Section 1.3). In our action plan, we will discuss a logical set of steps necessary to complete this task. Our approach clearly illustrates that Synergy understands the problem domain and the range of resource variables that must be addressed.

1.1 Statement of the Problem

We have reformulated the problem statement as three succinctly stated research questions to focus our research and our model hypothesis:

1. *Does evidence exist that past DMP programs contributed to weapon system readiness or weapon system sustainability — directly or indirectly?*
2. *If positive evidence of contributions to readiness or sustainability is found, can it be generalized, quantified, and credibly projected into the future?*
3. *If useful and verifiable quantification is achieved, can it be codified and incorporated into a decision support architecture and used to defend DMP budgets?*

These questions will provide a framework for client review and offer the opportunity, at each stage, for the client to continue or to halt further research if useful relationships are not found.

Downsizing of the military force structure with the resulting reduction in the DOD budget is placing extraordinary pressure on the Services to justify, in objective and quantifiable terms, each program by demonstrating its contribution to required U.S. combat capability. One of the Army's largest annual programs is depot maintenance.

Other models currently exist to assess capability constrained by logistics commodities such as reparable spares, munitions, fuels, and support equipment. Analyses at the weapon system-level provide projections of readiness and sustainability as a function of the inventories, stated requirements, and the funding for these commodities over the years of the POM. The requirement is similar, in general, to the commodity models calling for a dollars-to-capability model, where resource inputs are measured using dollars as a proxy and where capability outputs are measured in terms of peacetime readiness (weapon system availability). Despite this fundamental similarity, significant differences exist that must be addressed when considering DMP.

For logistics commodities, there are well-defined relationships between weapon system operations and requirements and consumption that, together with a wealth of cost and pricing data, provide a definition of reliable cost-commodity-capability links. Using these relationships, models can be exercised to project capability as a function of available funds or, *vice-versa*, to estimate costs required to support a desired level of operational capability. These relationships are possible because (1) commodity requirements and projected consumption can be statistically estimated as a function of weapon system operation; (2) commodity costs are known and well documented; and (3) lack of one of these commodities has a direct and immediate impact on mission capable rates. In short, without a required commodity, the weapon system is non-operational.

DMP is different. These three conditions are not present. First, requirements are based on detailed engineering analyses. Thus, DMP requirements are not as directly relatable to weapon system optempo as in the consumption of commodities such as POL or Ammunition. Second, because work packages for DMPs are negotiated and subject to change, cost or pricing data may vary and be obscured. Finally, management policies permit systems to be operational beyond suggested DMP cycles (knowing that cycle recommendations usually provide for wide margins of safety), so we may not assume that lack of DMP will immediately deadline weapon systems. To be sure, lack of maintenance, or lower frequency of maintenance, has debilitating long-term effects, which must be quantified.

For this study to be successful, it must focus on (1) understanding and specifying the DMP requirements process; (2) identifying DMP funding factors and constraints; (3) understanding the effects of weapon system inventory and activity levels; and (4) quantifying the impact of DMPs on weapon system capabilities. A model that links costs, DMP cycles, and weapon system operations is required to articulate a response to the question, "What happens if the Army doesn't get enough funding for all DMPs?" Building a repeatable process to quantify answers to this question in terms of military capability measures is the ultimate goal of this task. Achieving this goal requires research and analysis of DMP requirements, budgets, and changes in reliability, maintainability, performance, safety, and operating and support costs. A general model of the process is depicted in Figure 1. The primary focus of this task is on weapon system reliability and maintainability, characteristics which are traditionally related primarily to weapon system readiness and secondarily to weapon system sustainability.

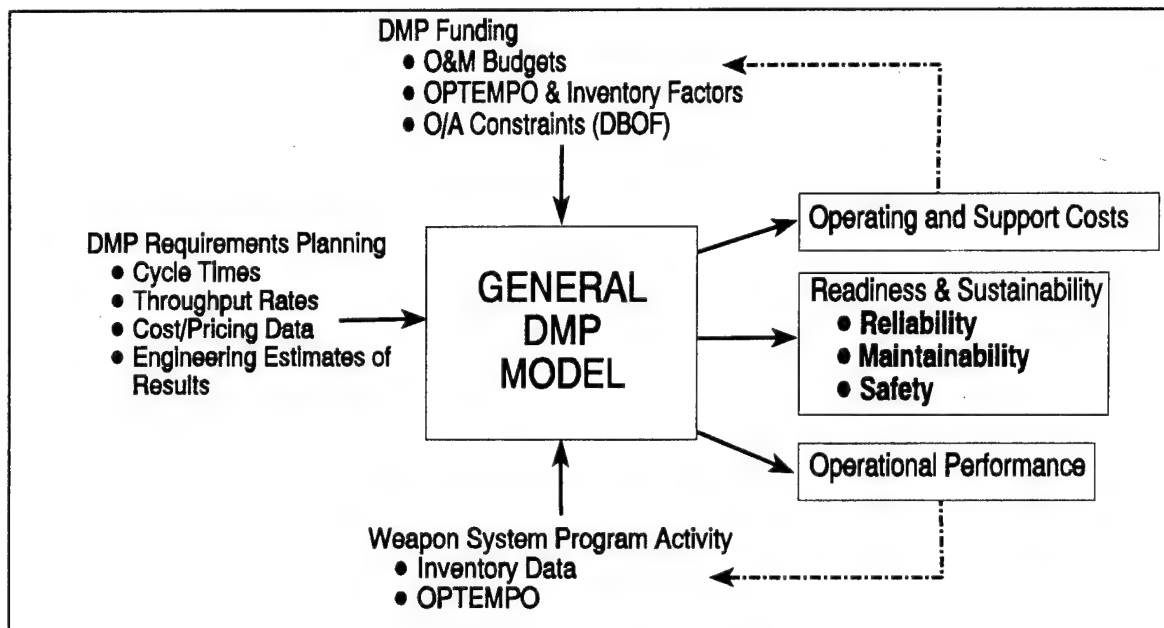


Figure 1. DMP Model Concept

1.3 Action Plan

This action plan is designed to address sequentially the three problem statements posed for this project. The project incorporates four subtasks: (1) Research and Literature Analysis, the objective of which is to answer the first research question; (2) Quantification Methodology, which focuses on the second research question; (3) Developing the stand-alone Proof-of-Concept Model that focuses on the third research question; and (4) Final Task Report, which summarizes the results of the research, analysis, and modeling effort; describes the

approach for integrating the DMP model into the appropriate decision support architecture; and provides the roadmap of future actions.

1.3.1 Subtask 1 — Research and Literature Analysis

In this subtask, we will conduct an extensive literature search, explore the DMP requirements process, enhance our understanding of how DMP is funded, develop at least one historical example around each of three weapon systems, and prepare a technical report and briefing on our findings.

Literature Search

While Synergy already has extensive knowledge of the DMP program and supporting processes, we recognize that a literature search is essential to improving the efficiency of every subsequent step in the project. For this phase, we will focus on gaining a complete and up-to-date understanding of each facet of the DMP program.

Analysis of DMP Requirements and Funding Processes

As part of our initial research, we will fully explore the DMP requirements process and how DMP work is justified and funded. In this section, we will describe how the Army develops DMP requirements and how recent changes in financial accounting systems affect the funding of this program.

DMP Requirements

DMP is a maintenance process under which weapon systems are inducted into the depot on a periodic basis. Timing varies by weapon system but generally ranges between 4 and 6 years. Several factors drive the DMP induction cycles and task requirements. Repair requirements are somewhat predictable based on cumulative hours operated by the fleet. Other problems are identified through inspection programs. Weapon system age may also be a good predictor of DMP requirements in some cases.

During the research phase of this task, we will review the details of the requirements process and identify how it is applied for three weapon systems. Specific task objectives are to identify cost-benefit relationships for the proposed DMP work packages. Once DMP work packages are approved and undertaken, they are paid for through the DBOF.

DMP Funding and Financial Management

Historical Examples

During this research and analysis phase, we will select one appropriate historical example for each of the three specified weapon systems as case studies. The objective of these case studies will be to answer the first research question:

Does evidence exist that past DMP programs contributed to weapon system readiness or weapon system sustainability — directly or indirectly?

For each example, we will identify the weapon system population affected, review cost estimates and actual incurred costs, review predicted benefits and attempt to measure actual performance benefits. Then we will attempt to translate actual benefits into direct or indirect improvements in weapon system readiness or sustainability.

We anticipate using regression analysis on time series data to quantify relationships between DMP work performed and weapon system performance. We will emphasize statistically significant performance measures that reflect weapon system reliability and/or maintainability changes to facilitate translation into readiness or sustainability terms, but we also may discover other performance measures that are strong indirect indicators of improved capability or reduced operating costs.

We propose one trip to each appropriate depot and HQ AMC for research and data collection. Topics for discussion will include the DMP requirements process, contingency plans for reduced funding scenarios, costing procedures, and problem areas, if any. Potential reliability and safety problems associated with weapon system operations beyond the DMP cycle times will be addressed. We will study the engineering analyses performed to develop inspection and maintenance cycles for subsystems and components and interview cognizant engineers to determine the relationships between cumulative operating times beyond the depot induction limit and failure probabilities.

At the conclusion of these initial analyses, we will prepare a briefing and draft a technical report summarizing the results of the research and, if positive and statistically significant indicators are present, recommending continuation to the next phase of the study.

1.3.2

Subtask 2 — Quantitative Methodology

If the initial phase of the research warrants continuation based on observations and results from the weapon system case studies, the second major subtask will be undertaken. This subtask includes the exploration of quantitative methodologies to relate DMP budgets to weapon system readiness and sustainability. The second research question will be addressed:

If positive evidence of contributions to readiness or sustainability is found, can it be generalized, quantified, and credibly projected into the future?

Potential Effects of DMP Funding Shortfalls

DMP funding shortfalls may manifest themselves in a number of ways that directly affect weapon system availability. The DMP budget for a weapon system in a given year is based upon the planned number of DMPs to be performed during that year. If there is a shortfall, some of the scheduled DMPs near the end of the year may be deferred to the next year. Further, some nonessential tasks may be eliminated. Consequently, it is possible that no weapon system will be deadlined in the near term.

In the long run, shortfalls in the DMP budget may drive downsizing of maintenance infrastructures that, in turn, leads to a diminished depot ability to complete DMPs within the allotted time frame, creating a queue of weapon systems for induction. When a weapon system has reached its time limit and cannot be inducted into the depot, the Army may extend the cycle for several months or approve additional operating hours. After that extension, the weapon system may be deadlined or additional extensions granted (with or without operating limitations). Other measures may include deferring certain DMP tasks or sending maintenance crews to support facilities to perform reduced DMPs on site. However, if funds are short during subsequent years, additional deferrals may accumulate. At some point, weapon systems awaiting induction may be deadlined — NMCM.

If DMPs are deferred and the weapon system continues to operate, the reliability, maintainability, and safety of the system are potentially affected. Structural Integrity may degrade beyond the normal limits, corrosion may become critical, and failure rates of certain nonelectronic components may increase significantly. Overall, weapon system break rates and repair times may increase with operating hours beyond the normal DMP cycle. As these rates increase, both NMCM and NMCS rates will be adversely affected, and the cost of recovery may increase dramatically.

Thus, deadlining weapon systems and operating weapon systems beyond the DMP cycle increases NMCM or NMCS rates, directly affecting readiness. Materiel readiness decreases adversely affect sustainability by reducing the number of mission capable weapon systems available at the beginning of a conflict. Also, lower weapon system reliability will cause more systems to break during wartime operations, decreasing combat effectiveness.

Quantitative Approaches

Our analytical approach first addresses the impact of deadlined weapon systems on readiness and sustainability, and second, the more complex problem of estimating the potential decrease in reliability and maintainability resulting from deferred DMPs.

These two effects on capability bound the problem:

- Relate DMP funding shortfalls to reduced depot production and deadlining of weapon systems.
- Relate DMP funding shortfalls to decreased weapon systems reliability and maintainability due to operating beyond DMP cycle times.

Deadlining of Weapon Systems

Weapon systems are inducted into the depot for DMP at specified time intervals, generally every 4 to 6 years. To analyze the impact of DMP budget shortfalls on weapon system readiness, the relationship between the budget and depot capacity must be established. Small decreases in the budget from the full funding level are likely to have little, if any, affect on depot capability. Less critical tasks can be eliminated, and other tasks can be reduced in scope without a significant consequence. However, when funding decreases further, the maintenance infrastructure must downsize to remain cost competitive under DBOF rules. This, in turn, reduces DMP throughput capacity or increases depot flow time. Flow time can be translated into throughput, measured in terms of DMP completions per time unit, assuming a steady input with no downtime awaiting inducted weapon systems. Thus, the relationship between funding and throughput may follow the general shape of the nonlinear marginal return function depicted in Figure 2.

The conceptual framework for the deadlining model is addressed in terms of the flow of weapon systems in and out of the depot and the resulting effect on weapon system readiness, as depicted in Figure 3. In the figure, depot inductions are drawn from the ranks of On-Hand weapon systems, excluding deadlined systems. Induction requirements are based on the average number of systems and the required DMP interval. Depot throughput rate is a function of the budget level. The actual induction rate is constrained by depot throughput capacity. Engineering data are used to estimate the probability of weapon systems

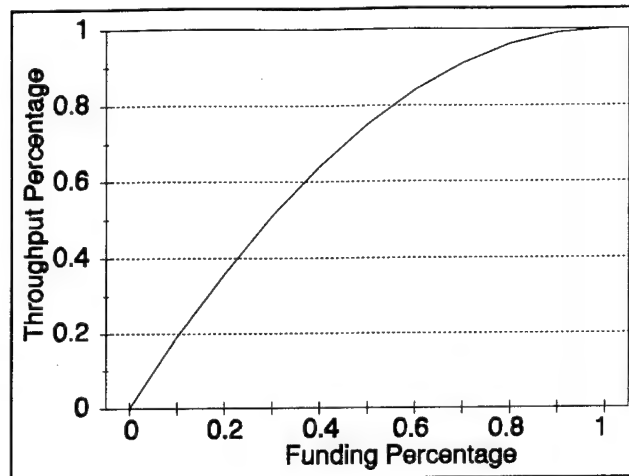


Figure 2. Depot Throughput Funding Relationship

being deadlined prior to DMP, based on time since last DMP. As budget shortfalls reduce the throughput rate, as shown in Figure 2, the number of deadlined systems increases. The flow of weapon systems through this model can be formulated as a dynamic process over time. An increasing ratio of non-operational weapon systems to On-Hand (deadlined plus undeadlined) weapon systems is reflected as an increase in the weapon system NMCM rate. For modeling purposes, non-operational weapon systems are assumed to remain at DS maintenance, classified as NMCM. Under full funding, the required induction rate and the throughput rate should be equal, and few — if any — weapon systems will be non-operational. With funding shortfalls, the required induction rate exceeds the throughput rate, resulting in an increasing number of systems beyond required DMP interval, which translates to deadlined weapon systems. Weapon systems not deadlined are processed through the Reliability Model discussed in the next section.

In summary, the computations are shown in Figure 3 and outlined as follows:

- Compute the throughput rate from the DMP funding ratio using the relationship shown in Figure 2.
- Compute the scheduled induction rate from the induction cycle and On-Hand weapon system population.
- Determine the number of deadlined systems at the end of each year based on the throughput and required induction rates, engineering data, and the status at the beginning of the year.

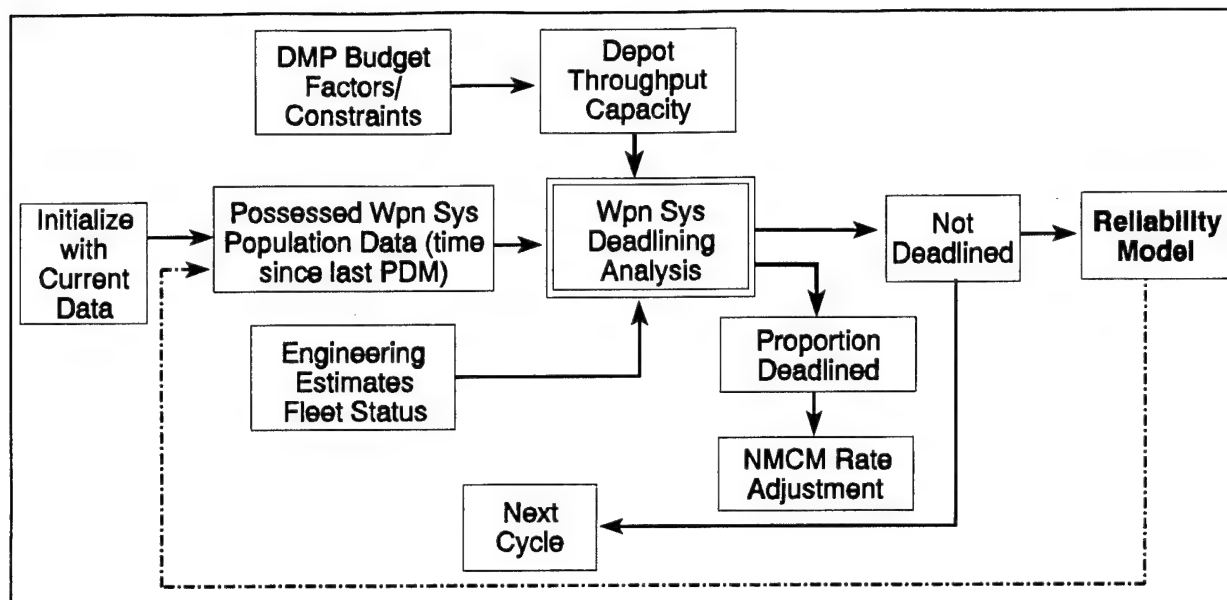


Figure 3. DMP Cycle (Deadlining Model)

- Estimate the average NMCM rate adjustment for the year due to deadlined systems.
- Combine this NMCM adjustment with the NMCM and the NMCS adjustments from the Reliability Model and other readiness models to obtain the MC rate.

In actual practice, deadlining of weapon systems in strict adherence to the DMP limit is not likely. However, deadlining become more probable as systems continue to operate for longer periods without DMPs. Before reaching the extremes of weapon system deadlining, reliability, maintainability, and safety will begin to suffer. A comprehensive approach involves a combination of deadlining results with a second methodology that addresses gradual erosion of reliability.

Decreases in System Reliability or Maintainability

The second effect of underfunded DMP (increased failure rates and/or repair times) may occur when weapon systems continue operating beyond their scheduled induction times. This requires an analytical approach that relates weapon system reliability, maintainability, optempo and DMP budgets. Of all the Work Unit Categories on a weapon system, relatively few are involved in the DMP process. Increased failure rates and extended repair times of potentially troublesome weapon system parts and other mechanical components will increase with age. Age for a component may be measured in terms of miles traveled, hours of operation, rounds fired, time in service, or some other measure of usage. We are

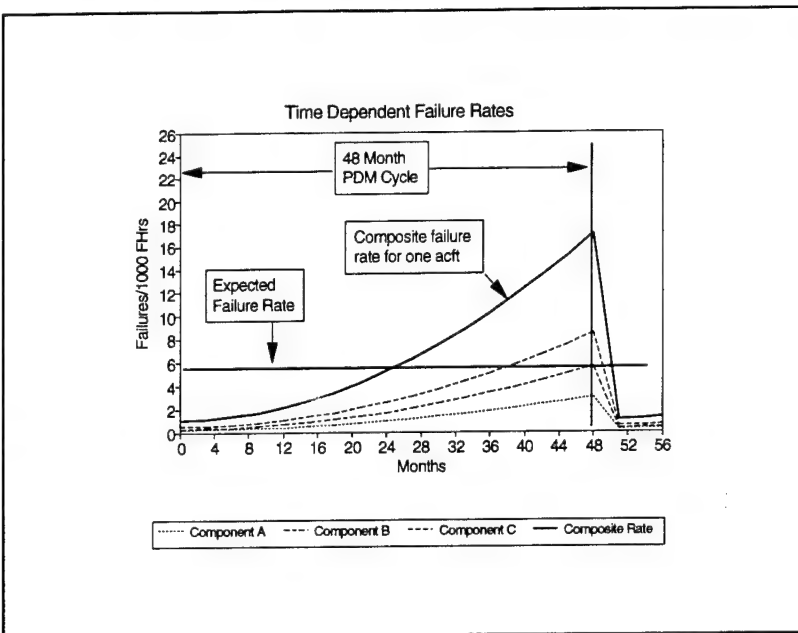


Figure 4. Failure Rate vs. Cycle Time

concerned with the portion of the overall weapon system failure rate attributable to fatigue, corrosion, and other categories of maintenance subject to DMPs. Major weapon system components subject to failure patterns behave similarly, but at different rates of degradation. DMPs can bring component and weapon system failure rates back toward a nominal baseline level, shown in Figure 4. The composite curve represents a single weapon system over a specified period beginning with a DMP and extending beyond the next scheduled DMP.

At the fleet level, DMP cycles can be combined to calculate a fleet-wide failure rate. If the DMP cycle is extended, the expected composite failure rate will be higher and the difference between the mean failure rates would illustrate the reliability reduction related to the DMP cycle extension.

To determine the shape of these component curves for specific weapon systems, a Weibull risk analysis can be used. This technique has been used in a variety of applications, including engine components, hydraulic components, etc. The Weibull probability distribution function can be written as:

$$F(t) = 1 - e^{-\left(\frac{(t - t_0)}{\theta}\right)^\beta}$$

where

t = age in units of wear (miles traveled, operating hours, rounds fired, or other measures)

F(t) = cumulative probability of a failure by age t

e = base of the natural logarithm

t₀ = minimum age at which a failure can occur (normally set equal to 0)

β = shape parameter

θ = scale parameter

A Weibull analysis requires a significant amount of failure data on each part. Generally, sample sizes of 20 to 30 are desirable. For each sample, data on the age and failure occurrences are collected. Age is measured in terms of the primary usage parameter affecting reliability, such as operating hours, miles traveled, sorties, engine cycles, etc. The vast majority of parts will experience no failures over the time period, but some parts will fail at an increasing rate. The data to be analyzed are the cumulative number of failures at each time period. Examples of the cumulative component failure rates for each of three components (or subsystems) on a weapon system reliability are illustrated in Figure 4. Finding the composite effect on overall weapon system reliability (shown as the composite curve) is a complex statistical problem.

Estimating the overall weapon system risk probabilities as a function of DMP cycle time requires a means of combining the failure characteristics of the critical components and the DMP schedules. A Monte Carlo simulation model can address the complexity intrinsic in the relationships between the individual failure distributions and the DMP schedules. The basic inputs to the model include a DMP schedule for each weapon system in the fleet (based on standard DMP intervals), programmed optempo, and failure probability distributions for each critical component. The relationship between optempo and the component aging parameters must be specified for each component or component failure mode. For example, if failures of a component are directly related to operational

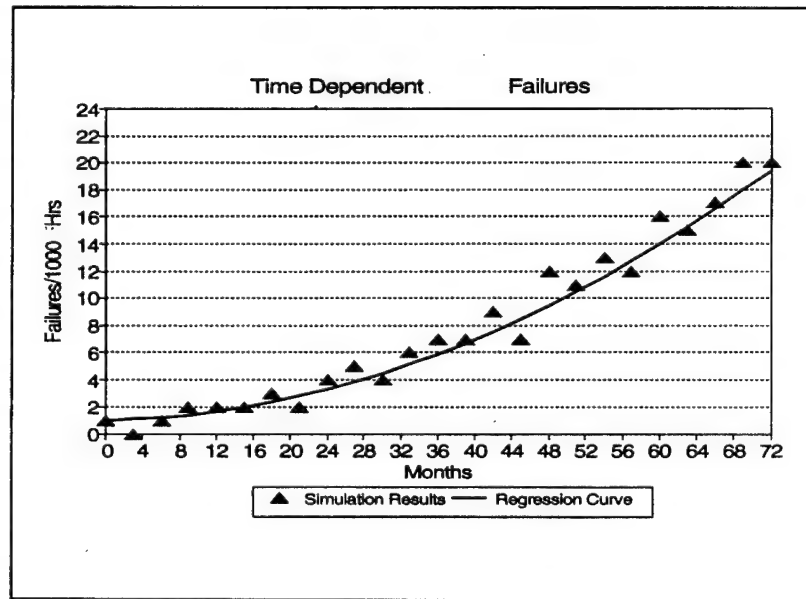


Figure 5. Failure Rate vs. Months to DMP

cycles, the average number of cycles per operating hour must be specified. The model must keep track of each critical component in each weapon system in terms of the time since the last DMP. Failures are simulated using a random (Monte Carlo) process, and maintenance actions reinitialize the failure distribution to good-as-new status. A sequence of model runs can generate an overall probability distribution of weapon system failures. A failure of any one critical component registers as a system failure. The number of failures (cumulative) that occur at different time intervals are recorded. The model can be exercised for the baseline case with DMPs performed as scheduled and the budget shortfall case with deferred DMPs. Statistical regression analyses are applied to these data to develop parametric equations expressing the relationships between alternative DMP intervals and failure rates, as depicted in Figure 5 (previous page).

The simulation model generates a curve of the increased weapon system failure rate over time for a given budget level relative to the baseline case of full DMP funding (Figure 6). Performing the computation over

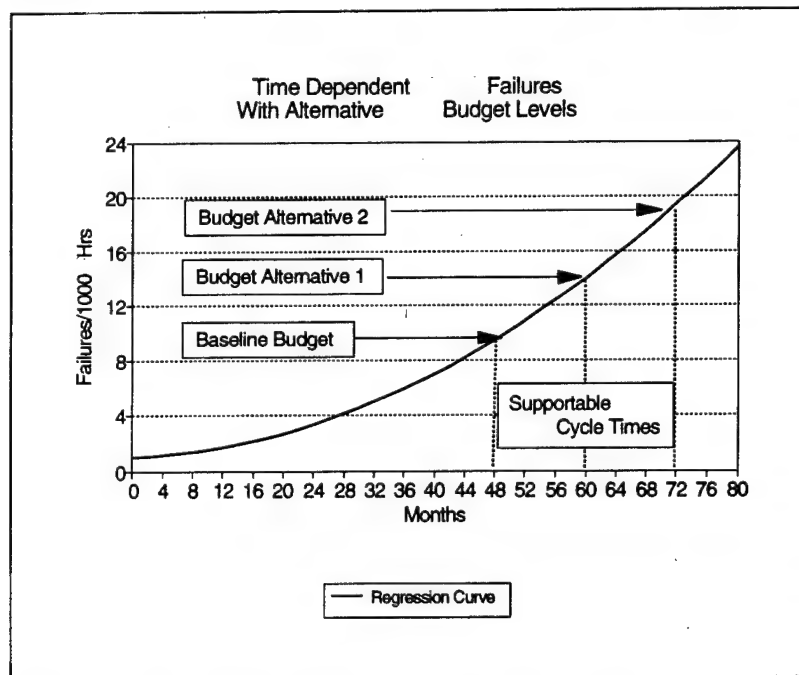


Figure 6. DMP Budget Impact on Failure Rate Trend

a series of budget levels yields a set of output data relating the failure rate trends over time at different budget levels.

The failure rate is then translated into impacts on NMCS and NMCM. Once composite aircraft failure rates are developed, they can be translated into NMCM and NMCS rate deltas for different budget levels, which are added to the NMCM and NMCS rates for weapon system components that are not affected by DMPs. How these two NMC categories are affected depends upon the

maintenance characteristics of individual components, in terms of the mean times between critical failure and mean repair times. Given the baseline weapon system NMCM and NMCS rates, the portion corresponding to the critical components must be established. For these components, the increases in their contribution to weapon system NMCM and NMCS rates will be determined and proportionately applied to the overall system rates to determine the average increase in weapon system NMCM and NMCS rates over time. Figure 7 illustrates the effect on total NMC rates expected to be observed when DMP cycles are extended.

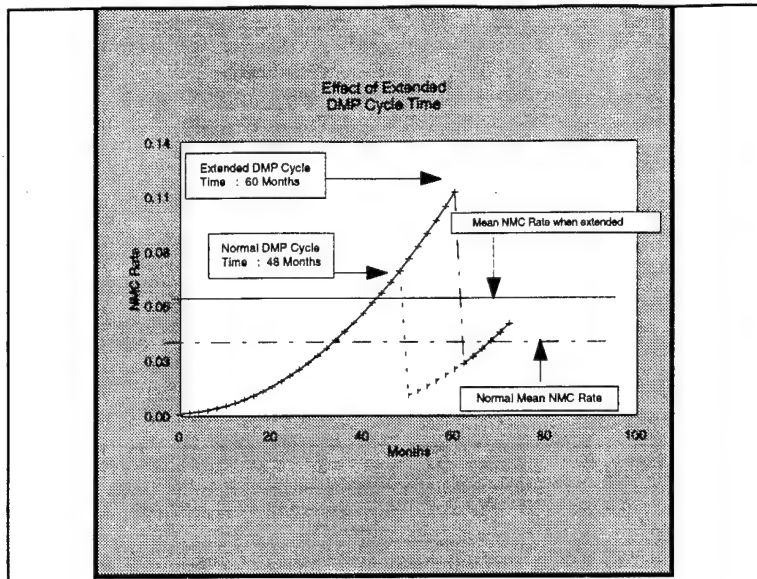


Figure 7. *TNMC Rates vs. DMP Cycle Time*

The overall flow of the process for the Reliability Model is shown in ?. In the preceding discussion, it is assumed that age-related failure data have been collected and analyzed for the critical components. Time and resource constraints on the study preclude generating such data if they do not already exist. The actual development and implementation of this process depends upon the form and availability of the pertinent component reliability data. (Data availability will be

determined during the research phase of the task.)

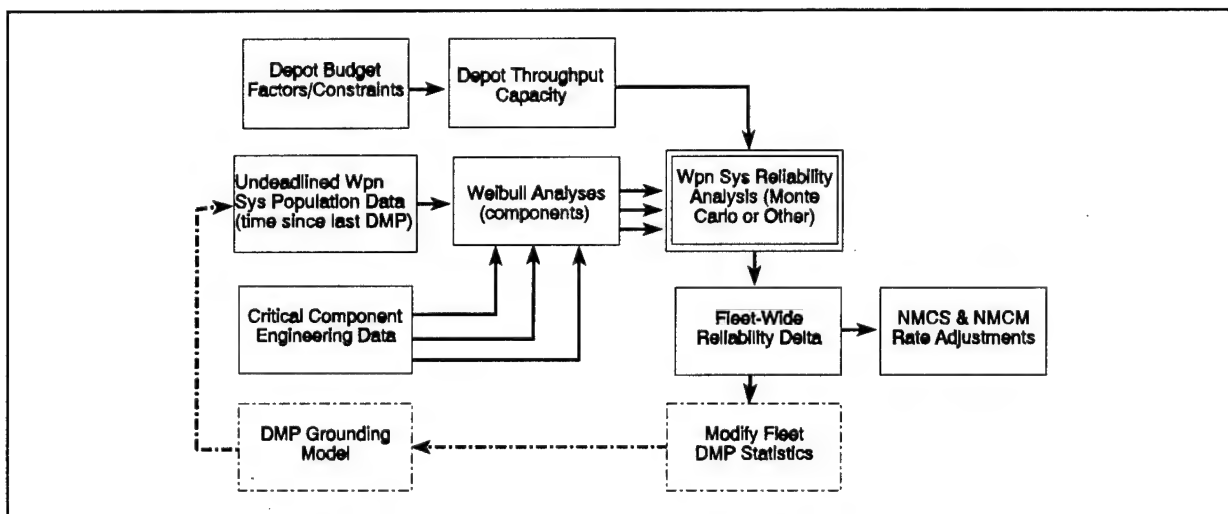


Figure 8. *DMP Cycle (Reliability Model)*

The proof-of-concept model will include the Monte Carlo computer program for developing the time-related risk assessment and the regression equations relating failure, NMCM, and NMCS rate increases to DMP budget shortfalls.

Combining the Analyses

If DMPs are deferred for a specified period and then the weapon systems are non-operational, the analysis involves a combination of increased NMCS and NMCM due to increased failure rates and increased NMCM due to non-operational weapon system. Such a situation could easily be integrated into a single Monte Carlo model, or the results of the two models combined in a separate computation.

To perform combined analysis on a weapon system, the following steps are required:

- Determine the critical components whose failures are likely to increase as the weapon system operates beyond the recommended DMP cycle time.
- For each component, determine the primary failure modes and the operational usage (age) parameter associated with these modes (operating hours, miles traveled, cycle times, etc.).
- Obtain data on failures vs. age, and estimate the Weibull parameters for each critical component.
- Using the Monte Carlo model, estimate the weapon system failure rate over time for the DMP critical components for the baseline and budget-limited cases.
- Translate the increase in failure rates to NMCM and NMCS rate adjustments.
- Combine Deadlining model analysis results with the results of the Reliability Model.
- Combine rate adjustments with overall weapon system NMCM and NMCS rates from a model such as FAMMAS.

Reporting the Results

At the conclusion of the quantitative methods investigation, a draft technical report and briefing will be prepared that answers the second research question. Should the suggested answer be negative, this report will constitute the final report for this task; if not, the report will contain specific recommendations for continuation into the third subtask, described in the next section.

1.3.3

Subtask 3 — Developing the Proof-of-Concept (POC) Model

This subtask includes an effort to develop a POC model, which combines the Deadlining and Reliability Models, to address the third research question:

If useful and verifiable quantification is achieved, can it be codified and incorporated into a decision support architecture and used to defend logistics DMP budgets?

This task will proceed based on the discovery of useful apparent relationships discovered during the previous phase and will result in a POC model designed around those predicting algorithms. The usefulness of this model will depend on two key assumptions that will be addressed during construction and initial testing of the model:

- The data required to operate the model are reasonably available
- The effects of DMP funding shortfalls can be isolated from other resource factors that affect readiness and sustainability

Probable Model Architecture

We will produce a stand-alone POC model with the calculator written in C++ and with a 4GL (probably Visual Basic) GUI. We suggest this approach as a low-risk option to build a testable model before initiating more costly interface and integration activities. The POC model design criteria will be compatible with the FAMMAS architecture.

Required inputs to the model will be identified during performance of the second subtask and will include detailed DMP requirements and funding data, by year and by weapon system. We anticipate that these detailed data will be available in army data bases. Other data will include required and past actual DMP flow times, historical weapon system performance data, and performance targets, as well as an expression of engineering estimates related to specific weapon system and component DMP requirements. Data will be gathered for the three weapon systems identified for this study and used for initial testing of the model.

The methodological studies in Subtask 2 will guide the development of algorithms for the POC model. We intend to develop parametric estimating relationships that link DMP funding streams to weapon system performance as measured by NMCM and NMCS rates. It is likely that the model will be designed to produce NMCM and/or NMCS adjustment factors rather than total estimated values for these performance measures. This concept is logical, since other resource areas such as DLR buy and repair programs affect NMCS rates and MACOM maintenance resources certainly affect NMCM rates. This means that the stand-alone POC model will be dependent upon nominal baseline input values for NMCM and NMCS to compute differences.

The model will also be designed to accommodate differences between weapon systems relative to differing effects on NMCM and NMCS rates. For instance, we may observe that DMP programs dramatically affect NMCM rates on one weapon system while other DMP actions may have an equally dramatic effect on failure of selected mechanical components which could reduce NMCS rates. Finally, the expected results of specific DMP cycles for each weapon system will probably be different and some means for accommodating engineering estimates of results must be incorporated.

Model outputs will directly (or in concert with other models) demonstrate the impact of DMP funding on weapon system readiness in terms of NMCS and/or NMCM rates and will be designed to project 3 years into the future.

Integration Considerations

Since DMP program funding is not likely to be a totally independent predictor of weapon system readiness, it is essential to consider the need to integrate the POC model within a larger architecture. The outputs of the POC model must be designed for integration with FAMMAS outputs to provide a comprehensive view of weapon system readiness. Two approaches will be considered:

- Integration of the POC model algorithms within the current FAMMAS structure.
- Maintenance as a separate model with cross weapon system allocation features (such as FAMMAS) and a feature that produces an output that can be coupled easily with FAMMAS model outputs to produce a combined readiness assessment

During the construction of the POC model, we will keep both of these options open.

POC Model Testing

Model testing will be conducted using data for each of the three selected weapon systems. The testing program for the POC model will be designed to confirm the two assumptions noted at the beginning of this section, thereby arriving at a positive answer to the third problem statement. To accomplish this testing, historical MC rate and DMP funding data will be used, probably for a 6- to 8-year period, depending on availability of data. A mechanism will be developed to screen out effects of other resource programs such as DLR buy and repair programs, possibly by selecting a time period during which these other programs were fully or nearly fully funded.

This subtask will conclude with a briefing and delivery of the POC model software and source code. The briefing will fully explain the algorithms used in the model, the quantitative basis of those algorithms, and the results of the limited testing conducted on the model.

1.3.4 Subtask 4 — Final Task Report

The final subtask in this sample problem is the preparation of a final technical report (CDRL A005). Provided below is an outline of that report and our initial proposal of its contents.

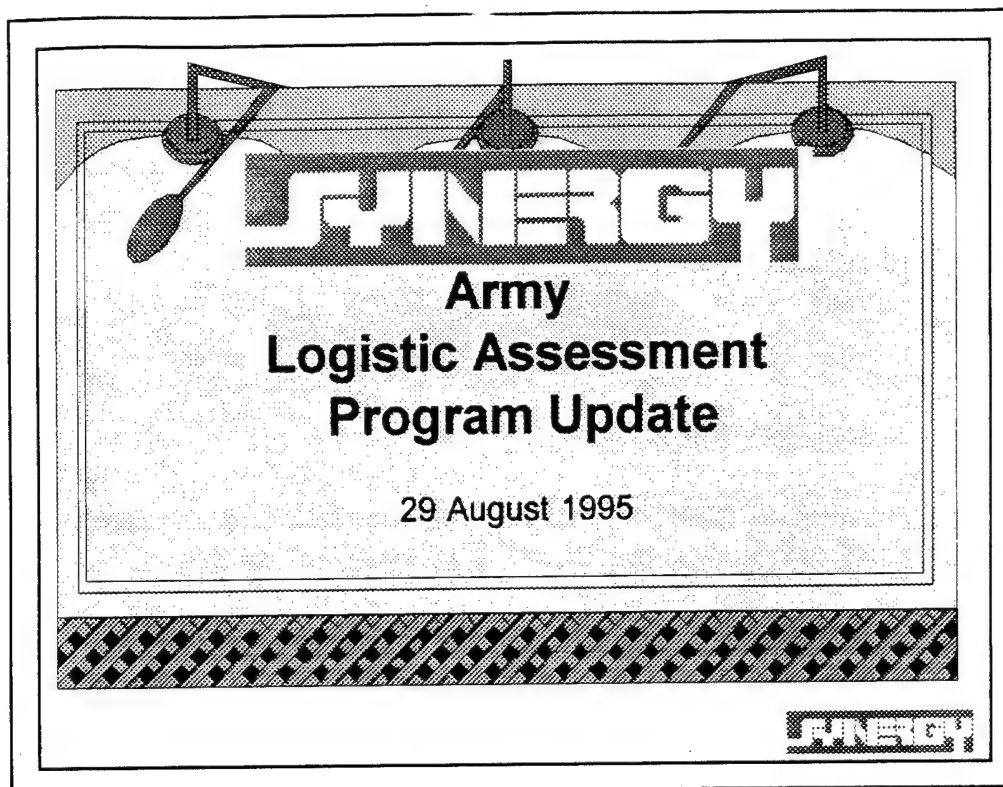
- A summary of the research and analysis findings
- An explanation of the quantitative methods explored for application to this task
- A technical explanation of the POC model produced that includes:
 - The data input requirements and sources for each
 - Explanation of the model logic
 - Requirements for serial or parallel integration with other models
 - Results of preliminary testing of the POC model
- Future recommendations to include a roadmap for converting the POC model to a full production model, to include:
 - An integration plan to incorporate the model into FAMMAS, if appropriate
 - Required FMS changes and source data automation suggestions

The foregoing sections clearly illustrate Synergy's grasp and understanding of the problem. We have presented a low-risk plan that allows for interim government decisions as the project progresses, with the option to terminate the task or redirect our efforts based on unfolding results. We have identified alternative analytical approaches that we will test during the course of our research and we described alternative methods for embedding the results in the Army decision support processes.

Synergy is confident in its ability to properly research the issues and develop powerful analytical methods to provide a credible DMP program and budget defense tool.

APPENDIX B

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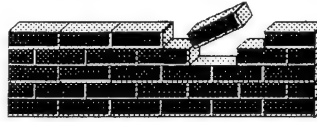
A decorative banner with a star on the left and a star on the right is positioned at the top. To the right of the banner is a graphic of a report card with the text "Report Card" and a large "A+" grade.

- To provide an Update on the Current Status of the ALAP
- To Obtain a Consensus on the Direction of Effort for Work Under the ALAP Contract

PDR 29Aug - HH

SYNERGY

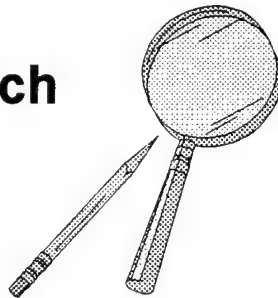
Current Work



- **Collect Wartime Data**
- **Address Sustainment/Contingency Issues and Tradeoff Analysis Among the 16 SORTS Weapon Systems**
- **Investigate Development of Wartime Version of FAMMAS**

FAMMAS

Research

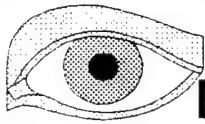


OSRAP

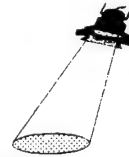
- **Optimum Stockage Requirements Analysis Program**
- **Similar Input Requirements - Both Predict Weapon System Operational Availability**
- **OSRAP Fulfills AMC Sustainment Analysis Requirements**

PDR 29Aug - ##

OSRAP



Refocus ALAP Effort Towards PDM Modeling



- Research
 - Issues
 - Trade-off Capabilities
 - O&S Cost
- Architecture Development
- Proof of Concept Model



Summary

- Synergy on Contract for work
- Original work planned no longer desired
- Alternative Projects identified and requested
- Synergy ready to refocus work effort
- Current Contract allows refocusing effort

PDR 29Aug - MW



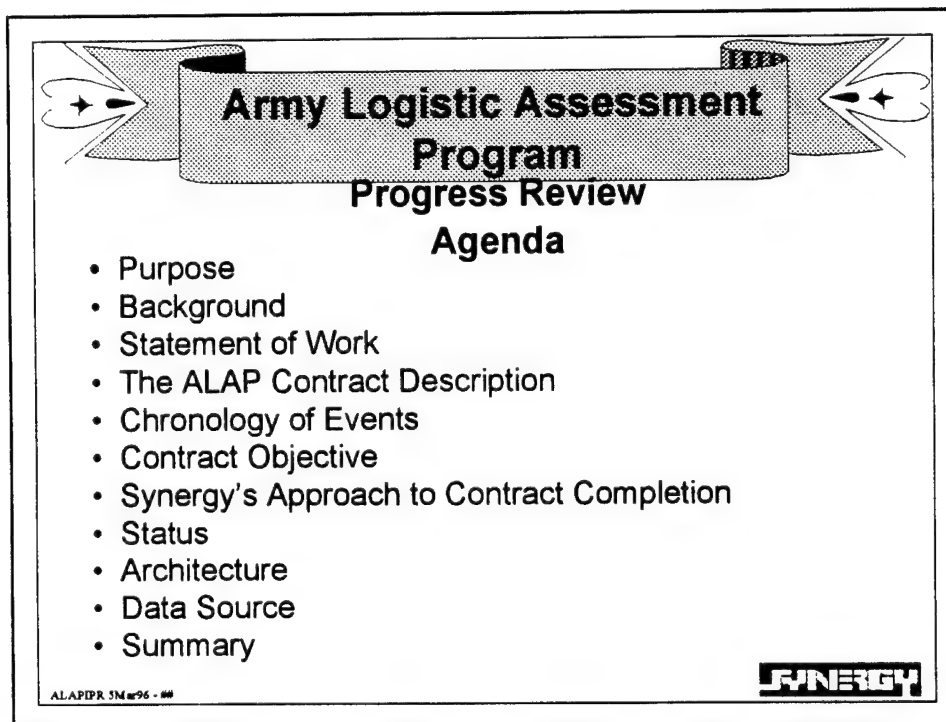
Decision

- Work on PDM Modeling
- Continue Work as currently written
- Work with Key Players to ID other areas of interest

FINLEY

APPENDIX C

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Army Logistic Assessment Program Progress Review

Agenda

- Purpose
- Background
- Statement of Work
- The ALAP Contract Description
- Chronology of Events
- Contract Objective
- Synergy's Approach to Contract Completion
- Status
- Architecture
- Data Source
- Summary

APendix D - D4



Background

FALL 1993:

- GEN(R) Thurman, on Meyer Readiness Task Force, Impressed with USAF FAMMAS
 - FAMMAS = Funding/Availability Multi-Method Allocator for Spares

DEC 1993:

- DCSLOG GEN. Salomon and DUSD (LOG) Mr. Klugh direct test on AH-64 Apache
 - Results were promising

ALAPIR 5Mar96 - 06



Purpose

- To Present an Historical Overview of Synergy's Army Logistic Assessment Program (ALAP) and efforts to complete the Project
- To Provide an In-Progress Update as of 5 March 1996
- To Preview the Projects Completion

AFendix D - D5

SYNERGY

Background Continued

MAY 1994:

- GEN Wilson directed test on all 16 Major SORTS systems
 - Including USMC M1A1 & HMMWV
- Completed initial testing on all 16 Major SORTS systems and results briefed up to Army Vice Chief of Staff level
- Synergy and DALO-RMI negotiate two (2) work efforts:
 - The first is to put FAMMAS in a Windows environment
 - The second is to enhance FAMMAS and conduct Wartime Logistic assessments

ALAPIDR 5M w96 - 00

SYNERGY

Background Why ALAP

- Army Logistic Analysis Program (ALAP) reasonable follow on and complement to FAMMAS
- Assesses the sustainability of weapons systems in multiple MRC scenarios
- POM tool to graphically to asses sustainability given a budget position
- Provide total Peace-to-War Funding Scenario

APendix D - D6



Statements of Work Confusion - One Contract or Two

FAMMAS -

Purpose

"...Development of an Army Readiness Model. The model will assess peacetime readiness..."

Work To Be Accomplished

The contractor will design an Army FAMMAS model in a Windows environment. The model will be subject to a Preliminary Design Review (PDR) and a Critical Design Review (CDR). A Critical Design review will be held to finalize changes to the model.

ALAP -

Purpose

"...Development of an Army Readiness Model. The model will assess peacetime readiness..."

Work To Be Accomplished

Perform wartime logistic assessments. The contractor will...install a separate module within FAMMAS which enables the logistics community to assess the impact on system readiness caused by MODs, Depot Maintenance, and common support equipment (CSE)

ALAP/PR 5M#96 - #6



Statements of Work

Confusion - One Contract or Two

FAMMAS -

Purpose

Development of an Army Readiness Model. The model will assess readiness readiness.

Deliverable

- Preliminary Design Review (PDR)
- Critical Design Review (CDR) Briefing
- Functional Description
- User's manual
- Software

ALAP -

Purpose

Development of an Army Readiness Model. The model will assess readiness readiness.

Deliverable

- Technical Report
- Briefing of Tech Report
- Update Functional Description,
- Update User's Manual
- FAMMAS Enhancement Software

ENERGY

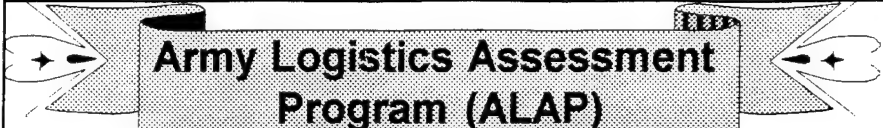
Army Logistic Assessment Program

A Basic Description

- A Multi-Tasked Project
 - Enhancements to FAMMAS
 - Assess the Development of an Army Version WINLAM (Sustainment Model)
- WINLAM - A Decision Tool
 - Macro-level Budget Analyses
 - Quick assessments of programming and budgeting decision impact on Sustainment Capability

ALAPDR 3M 96 - 00

ENERGY



Army Logistics Assessment Program (ALAP) A Chronology of Events

- 16 Jan 95 - Contract dated
- Feb 95 - Work Begins
- Apr 95 - First Meeting with Principal Players At LOGSA
 - ALAP Briefed as Wartime Version of FAMMAS
- AMSAA & AMC initial position -
"No More Requirement Models" - OSRAP

APendix D - D8



ALAP Vs OSRAP A Chronology



(Round 1)

- Apr - May 95 - Data Research for ALAP Model
Development Stops
- May 95 - OSRAP Fact finding begins
 - OSRAP - Stockage Requirement & Determination
 - ALAP - Wartime Sustainment, MC Predictive &
Budget Decision
 - Similar Input Requirements

ALAPDPR 5M 96 - 00



ALAP A Chronology

- Jun 95 - AMC assumes Project Oversight -
 - Briefed Findings of OSRAP Investigations to AMC
 - Model Development on hold until...
 - Synergy Turns efforts to FAMMAS Enhancement
 - Suggest other Tasks for ALAP Completion
 - Depot Maintenance Program
 - Integration of FAMMAS & OSRAP

APendix D - D9



ALAP A Chronology

- Jul 95 - Investigation and development of Programmed Depot Maintenance Model favorable to AMC
- Aug 95 - DALO-RMI reserves right to make decision on Project Alterations (Depot Maint Model on hold)
 - Request OSRAP briefing and demo
 - ALAP Model Development continues on hold

ALAPDPR 5Mar96 - #4



ALAP A Chronology

- Nov 95 - DALO-RMI gives "go-ahead" for completion of Proof-of-Concept Model
- Jan 96 - FAMMAS CDR/PDR
 - Personnel Changes within DALO-RMI
 - Reversal in thinking vis-a-vis Maintenance Module
 - ALAP Vs FAMMAS (Round 2 ?)

APendix D - D10

ENERGY

Army Logistics Assessment Program A Two Fold Objective

- Enhance FAMMAS by developing and Installing A Maintenance Module
- Investigate Possibility/Feasibility of producing A Wartime/Sustainment POM and Budget Assessment Decision Support Tool

ALAPDR 5M-96 - ##

ENERGY

Army Logistics Assessment Program

A Two Fold Approach

- **FAMMAS** Maintenance Module -
Identify key elements to NMCM reporting and replicate using available data Sources
- Sustainment Proof of Concept Model-
 - Research Army Wartime Logistic System
 - Research weapon system sustainment efforts
 - Identify and develop data sources
 - Replicate Logistic Sustainment System

APendix D - D11



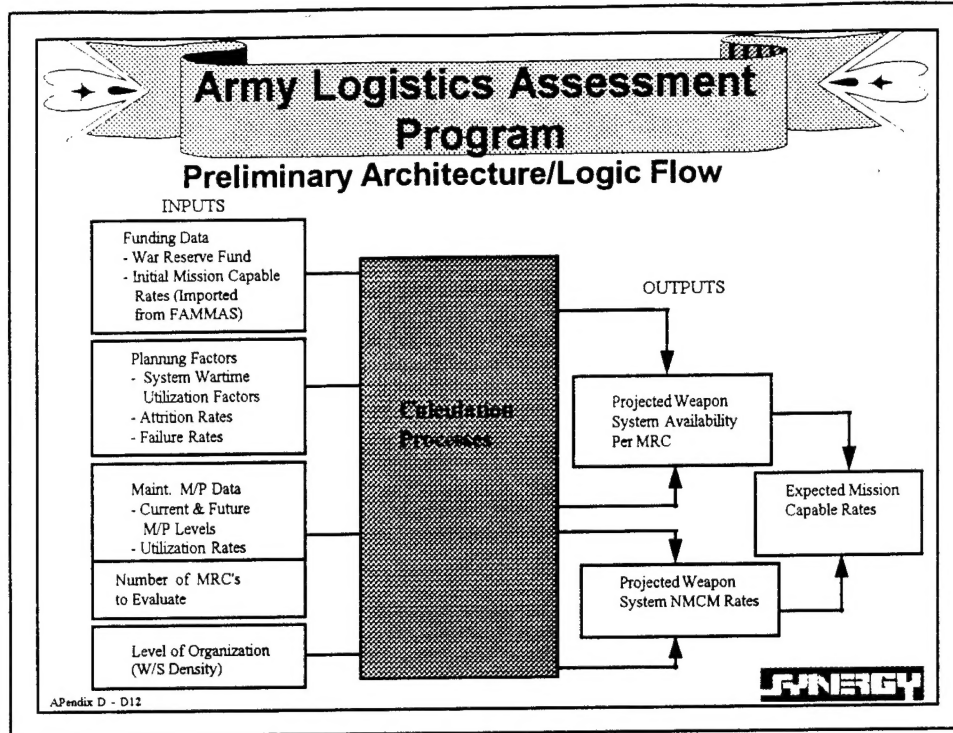
Army Logistics Assessment Program

Status of Development

- **FAMMAS** Maintenance Module
 - Completed - Installed
- Sustainment Model
 - Models Architecture in Preliminary Development
 - Data Sources identified - 90% required data collected
 - Algorithms currently being developed

ALAPDR 5Mw96 - 00





Army Logistics Assessment Program

DATA	DATA SOURCE
Initial MC & NMC Rates	Army FAMMAS
Weapon System Density by Force Structure	TRAC-Lee/CASCOM Operations Logistics Planner
Combat OPTIMO	Concepts Analysis Agency
Current & Future Manpower Rates	Personnel Command MOSLS
Attrition Rates	LOGSA Candidate Item File
Break Rates	

ALAPIPR 5M 95 - 00

Army Logistics Assessment Program

SUMMARY

Initial Objective

Perform wartime logistic assessments.
The contractor will...install a separate module within FAMMAS which enables the logistics community to assess the impact on system readiness caused by MODs, Depot Maintenance, and common support equipment (CSE)

Revised Objective

Because of the many start and stop delays, confusion among all involved regarding Project Coordinator, FAMMAS/ALAP confusion, project goals

Technical Report and Briefing
A Proof of Concept Model

APeodix D - D13

ENERGY

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